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THE INFORMATION SYSTEMS DECISION

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This report is one of a series under the aegis of the Productivity/ Quality project within MIT's Sloan School of Management. The Project Director is Thomas A. Barocci, Associate Professor of Management. For further information contact Ms. Carolanne Foilb, Project Administrator, Sloan School of Management, MIT, 50 Memorial Drive, E52-454, Cambridge, MA 02139.

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Investment decisions about information systems and computing hardware are usually made on the basis of faith. Most often, the competitive necessity to produce efficiently (whether perceived or real) forces the decision. Managers generally address the problem by simply investing and hoping. But by projecting and carefully considering the expected effects of the decision they could sharply reduce the faith component of this investment.

Almost all firms fighting to stay competitive in today's markets have to make information systems (I/S) investment decisions. At the same time, they must pay more attention to productivity than they did a decade ago. So when managers make these decisions, they seek to maximize expected pay-offs, including productivity improvements that result from I/S installations. But in order to compare I/S costs with expected benefits, managers will have to use benchmark productivity measurements by which they can later guage the value of an I/S investment. The point of I/S is not to confuse the

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productivity issue, but to raise productivity. The most fundamental challenge facing management is thus the necessity to view I/S and productivity in conjuntion with one another.

The productivity gap between the U.S. and its major competitors is widening rapidly. "Computerization," the primary concern of the seventies, has resulted in growing I/S costs, low software productivity, and the problems of coordinating complex computer tasks within and outside the firm. So the main problem we consider here is how I/S affect end user productivity. Our five cases are in the high-technology electronics and banking industries. All of the firms are large multinationals. We studied them by interviewing about ten people in each company and collecting around 100 questionnaires.

In the electronics industry, we focused on manufacturing and engineering -- both areas in which recent investments in I/S are common. In banking, computerization is noticeably on the rise. Manufacturing I/S include material requirements planning (MRP), inventory control, and shop floor scheduling control. In engineering we examined Computer Aided Design (CAD) systems, used to design printed circuit boards, integrated circuits (IC, LSIC) and mechanical parts. In banking we looked at how recent computerization (analagous to plant automation, rather than manufacturing control) affect process automation to increase productivity. The questions we addressed in all three areas were how useful these systems were in producing information on productivity, and how that information was used.

The body of our analysis is structured as follows. After presenting our company overviews, we first consider problems of measurement and the effects of these on productivity. We then look at intangibles that must be addressed with qualitative judgements. Finally, we discuss the ways in which investment philosophies -- justifications for the use of I/S -- can affect the usefulness of the systems and their impact on the firm and its productivity.

One major theme of our analysis is that a really insightful productivity analysis must consider outcomes rather than simply outputs. Outputs are units of products weighted by their respective prices. Output attributes and process constraints affect the outcome of the productivity project. Product attributes that typically affect a productivity outcome include quality, timeliness, adherence to specifications, variety of options, user satisfaction, and the effects of engineering changes and updates on customers, service, spare parts, training and documentation. Process constraints are secondary effects encountered during production, which are imposed by the interaction of the firm with its environment. Examples include environmental regulations, antitrust laws, miscellaneous legal requirements, financial obligations, and foreign exchange rates. The importance of considering outcomes rather than outputs lies in the simple fact that the productivity whole (outcome) is greater than the sum of its parts (outputs). Tangible changes in, say, the capital/labor mix, are paralleled by intangible changes in outcome; the latter are much harder to measure, partly because their effects are usually felt most strongly in the long-run.*

Productivity is measured in ratios; the formula is generally output divided by input in physical units, weighted in market dollar values. But these ratios are often inadequate. And there is no specific, company-wide method of setting up a meaningful system to improve them. Different industries have different kinds of productivity objectives. They depend, for example, on whether the

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*Michael Packer, "Output-Mapping: A Productivity Analysis Technique for R&D/Organizations," Laboratory for Manufacturing and Productivity, M.I.T., 1981, conference paper.

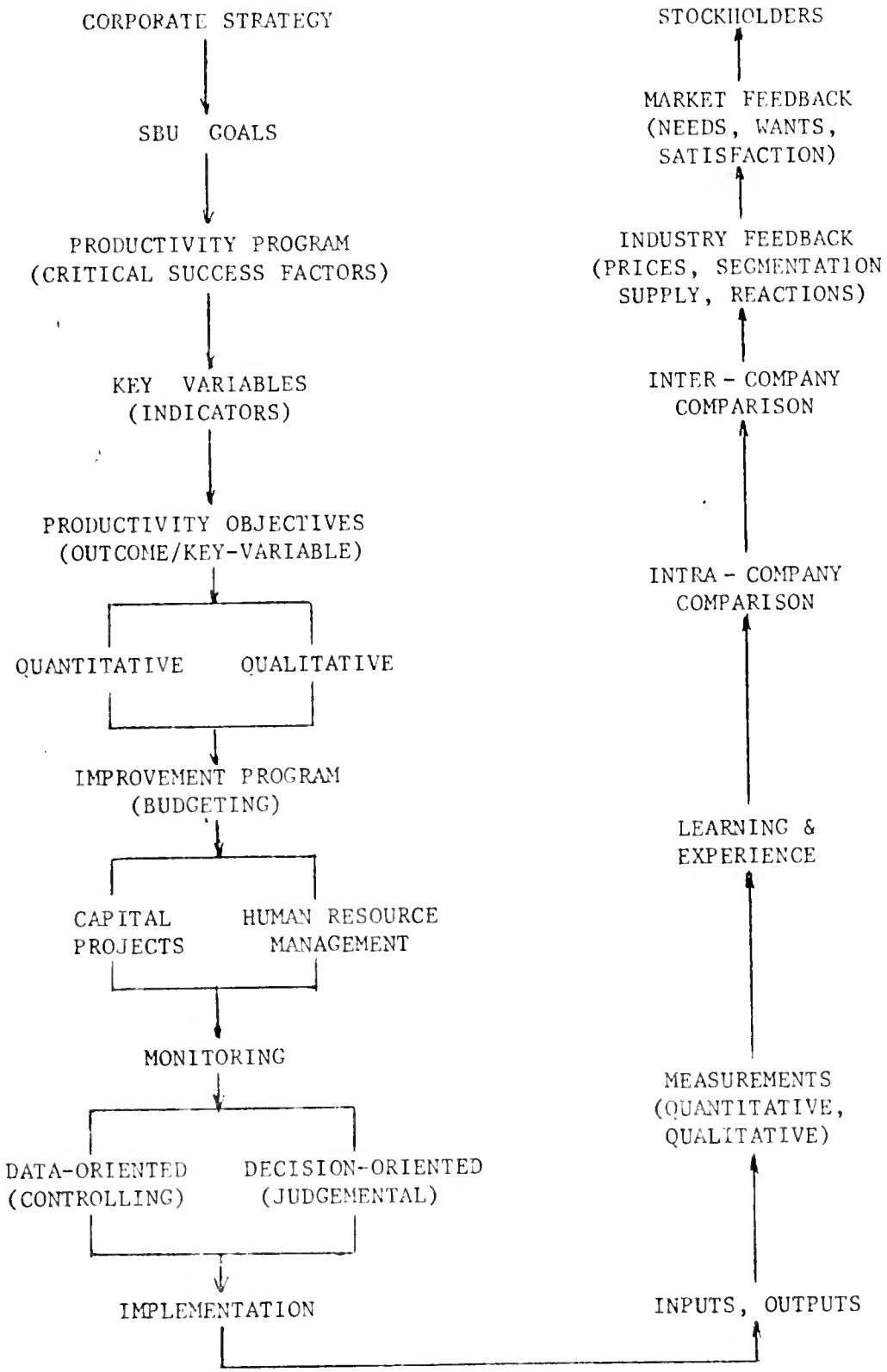
sector is capital- or labor-intensive. Productivity ratios can be measured on the basis of partial factor productivities, using only one input (e.g., labor). Or ratios can use aggregated inputs (in dollar values); these are called total, or total factor, productivity measures.

But even the firm with a clear understanding of these differences will encounter difficulties in at least three areas. First, some kinds of expenses (e.g., R&D, advertising or maintenance costs) may lower productivity figures so as to discourage management to incur these costs. Second, the gap between necessary and obtainable data is usually large. And finally, exogenous factors can result in uncontrollable or non-continuous changes in measured productivity -- changes which do not reflect the firm's actual productivity. Wildly fluctuating interest rates, for example, have no impact on the actual productivity of a bank. To address these and other productivity problems effectively, productivity programs must be related to the firm and function under consideration. But just as important is the need for managers to question purely quantifiable productivity measurements and to take into account the qualitative aspects of labor and capital investment productivity.

In designing quantitative and qualitative productivity measures, it should be kept in mind that I/S productivity is a management issue. It is up to management to design and evaluate efficiency and user satisfaction, grouping all measurements into qualitative and quantitative categories. To reflect the importance of management involvement in the productivity issue, we have based our study on the flow-chart pictured in Figure 1. The chart illustrates the primary stages a productivity program goes through from its inception to various aspects of the outcome.

The complexity of the productivity process and of the measurement not only of outputs, but of ultimate outcomes, pose many problems that enforce the haphazard nature of productivity-related I/S investment decisions. But any

FIGURE 1: The Productivity Process at the Company Level



viable firm must be efficient, any efficient firm must face the productivity quandary despite its complexities, and any efficient high-tech engineering or manufacturing enterprise must link its I/S with larger productivity goals. This last requirement is worth emphasizing, particularly since the explicit relationship between I/S and productivity is not of major concern to the firms covered in this study. The specific ways in which I/S and productivity are interconnected are illustrated in Figure 2.

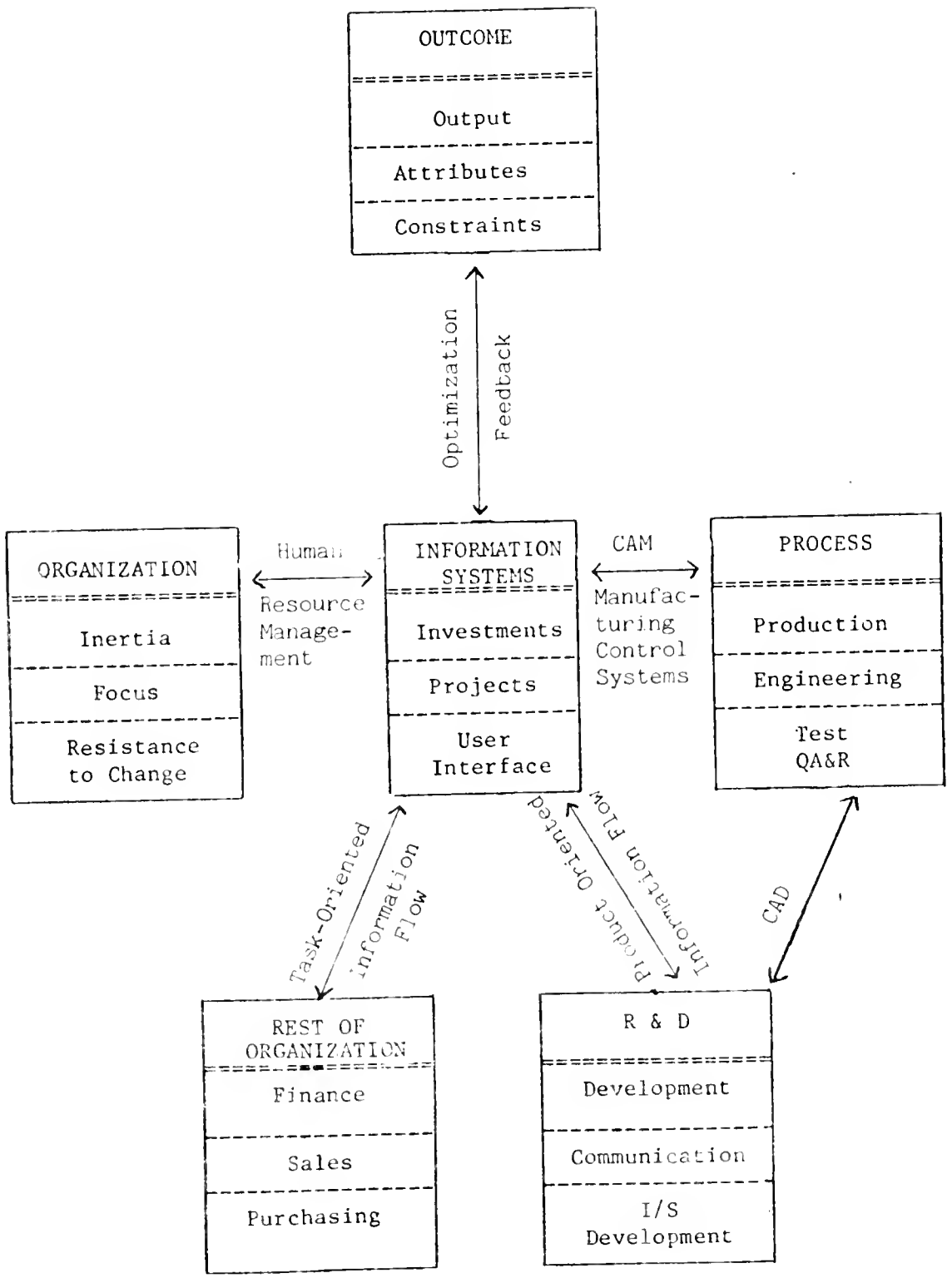
We conducted our field research with four large high-technology firms and one major bank, on the basis of personal interviews and questionnaires including a company survey, an interview guide and a check-off questionnaire for each area of concentration. The company survey covered general information, the firm's culture, productivity programs and measurements, and reward systems. This information provided us with a feeling for each company's broad approach to the productivity issue.

The interview guide was designed to give qualitative as well as quantitative background information about each area we examined. It covered the description of the systems in use, the relationship between each functional unit and the I/S department, computer investment history and philosophy, each unit's definition and measurement of productivity, and how productivity information was used. We compiled a version of the guide specific to each area of concentration: manufacturing, engineering, and banking.

The check-off questionnaire was answered by checking boxes, rather than writing short answers. It was composed for statistical analysis, using a seven-point scale to measure perceptions of the factors affecting productivity, the ways in which information systems affect these factors, the effectiveness of productivity programs, and the relationship between these and

FIGURE 2

The Role of Information Systems



other areas (e.g., the connection between an I/S group and manufacturing or engineering). Again, we used three versions of the questionnaire, one for each area of concentration.

We began by administering the company survey to a corporate manager with productivity responsibilities. Then we interviewed an average of 10 people at various levels of plant management, I/S, engineering, corporate manufacturing services, CAD groups, research and development (R&D), and corporate engineering support. At the bank, we spoke with corporate staff support, office managers and systems managers. The interviewees were for the most part very open, particularly in the high technology firms. The questionnaire response rate was 80%; the sample from each company is varied.

The firms we studied are referred to as: Atlasbank, a leading international bank; Comptech, a computer systems designer; Gruber, a producer of electronic instruments; Ratronics, a defense electronics firm; and Semcon, a manufacturer of semiconductors. Company overviews appear in Figure 3.

Because the banking and high technology industries are becoming more and more competitive, their focus on productivity has had to intensify. Because of the low direct labor content of high technology products, and the high percentage of knowledge workers involved, productivity programs in high technology enterprises emphasize overhead costs. In banking, the focus is on automating manual processing at the lowest levels. Most firms use the classical measure of productivity: output per employee hour. This measure is simple, controllable, and actionable at low levels. But the four high technology firms are also striving for quality-related productivity goals. The general productivity programs and their situational settings are laid out in Figure 4.

Figure 4 illuminates several interesting trends. It is apparent, for example, that Ratronics' hands are more or less tied at every level by the narrowly defined standards and requirements of its government contracts. This firm is not very eager to experiment with productivity. Its connection with

FIGURE 3: COMPANY OVERVIEWS

	ATLASBANK	COMPTECH	GRUBER	RATRONICS	SEMCON
SIZE	-- assets over $50 billion	-- 1981 sales, $2 billion	-- 1981 sales, $2 billion	-- annual sales, $200 million	-- annual sales, $1 billion
PRODUCT/ SERVICE	-- banking	-- computer systems design	-- electronic instruments	-- defense electronics	-- semi-conductors
EMPLOYEES	-- over 50,000 -- high lower-level turn-over -- long upper management tenure -- frequent union drives	-- 50,000 -- low turn-over, except I/S professionals -- engineering-oriented -- no union -- good labor relations	-- 50,000 -- low turn-over, except I/S professionals -- engineering-oriented -- no union -- good labor relations	-- 5,000 -- low turn-over, except I/S professionals -- no union -- good labor relations	-- 20,000 -- low turn-over, except I/S professionals -- engineering-oriented -- no union -- good labor relations
HISTORY	-- established before World War I -- conservative	-- founding engineers still in control -- clear-cut personalities and philosophies permeate firm	-- founding engineers still in control -- clear-cut personalities and philosophies permeate firm	-- military emphasis	-- founding engineers still in control -- clear-cut personalities and philosophies permeate firm
INDUSTRY DYNAMICS	-- increasing competition -- steady growth	-- increasing price competition -- fast growth	-- increasing price competition -- fast growth	-- highly competitive	-- increasing price competition -- fast growth

FIGURE 3: COMPANY OVERVIEWS (continued)

	ATLASBANK	COMPTECH	GRUBER	RATRONICS	SEMCON
CUSTOMER	-- personal accounts -- corporate financial management	-- civilian electronics users	-- civilian electronics users	-- federal government, Department of Defense	-- civilian electronics manufacturers
CULTURE	-- conservative -- formal -- slow to change -- no clear culture -- management by committee	-- participatory management -- consensus decisionmaking -- decentralized responsibilities -- no formal culture -- emphasis on technology, quality, service, price, PRODUCTIVITY	-- paternalistic -- people-oriented -- formal, uniform culture -- open atmosphere -- emphasis on technology, quality service, price -- strong CAD productivity emphasis	-- militaristic -- rigid hierarchy -- slow to change -- engineering-oriented -- strong CAD productivity emphasis	-- old-fashioned but open atmosphere -- informal, aggressive -- low-level participatory decision-making -- management by objective -- good employee-supervisor communications -- formal culture -- strong productivity emphasis
STRUCTURE	-- autonomous divisions by geographical area -- each division with different function and culture	-- complex, matrixed -- dynamic -- vertically integrated	-- vertically integrated -- small, autonomous divisions	-- multi-divisional	-- relatively centralized
I/S	-- computer automation of formerly manual jobs	-- division I/S groups report to division heads and corporate I/S -- VERY LOCAL responsibilities for I/S development and maintenance	-- division I/S groups sit with users, responsible for maintenance -- standard software from corporate I/S support -- slow decentralization since 1973	-- plans to decentralize corporate I/S, currently responsible for all I/S -- R and D, engineering have computers, develop software -- new manufacturing control system in 1974, but older contracts still prohibit use	-- centralized and slow to develop -- relatively backward except in CAD -- engineering has its own computers -- I/S people in plants act as user-interfaces

FIGURE 4 -- The Information System - Productivity Connection

	ATLASBANK	COMPTECH	GRUBER	RATRONICS	SEMCON
Productivity	-incrementally increase output/per employee hour	-incrementally increase output/per employee hour -quality-related productivity goals -shipping on time within quality standards, at mimimum cost	-incrementally increase output/per employee hour -quality-related productivity goals -shipping on time within quality standards, at minimum cost	-incrementally increase output/per employee hour -quality-related productivity goals -shipping on time within quality standards, at minimum cost	-incrementally increase output/per employee hour -quality-related productivity goals -shipping on time within quality standards, at minimum cost
Program	-low-level process automation systems with corporate support groups helping to improve productivity -recent success with QCs, to improve cost & quality	-first five year plan now in effect, decentralized with each group developing own program -corporate task force for knowledge worker productivity	-half-time productivity function -no formal programs except QCs -increasing division attention to continuous flow production	-limited by goverment standards and small lot sizes -no attention to worker productivity increases	-3 year old corporate productivity groups -6 formal management training courses
Manufacturing Control Systems	-N.A.	-master scheduling -material requirements planning -inventory control	-master scheduling -material requirements planning -inventory control -shop-loading and shop-floor control -capacity planning system -all systems developed in-house to interface with existing systems	-master scheduling -material requirements planning -inventory control -batch processing -non-automatic interfaces -inventory management systems out-of-date to conform to government contracts -software program updated since 70s, but ineffective for cost and personnel allocation	master scheduling -material requirements planning -inventory control -manufacturing control system continually updated

Capital Investment Strategy for Manufacturing	-N.A.	-no formal strategy	-formal computer investment strategy and post-implementation evaluation -long-term planning for future systems development with division involvement	-no formal strategy	-no formal strategy
Manufacturing System Acceptance & Training	-N.A.	-N.A.	-formal training for users of manufacturing control systems	-no project post-implementation evaluation -formal training for users of manufacturing control systems	-problem with timely, accurate and non-conflicting information -complex system, so no intermittent use -on-the-job training only
Productivity Measurement in Manufacturing	-N.A.	-inadequate measurement on the basis of direct labor input	-inadequate measurement on the basis of direct labor input	-inadequate measurement on the basis of direct labor input	-inadequate measurement on the basis of direct labor input
Engineering Productivity	-N.A.	-CAD, but development and maintenance responsibility rests with R&D, not with I/S -CAD integrated with manufacturing control -too many generic CAD functions and systems for easy use	-CAD, but development and maintenance responsibility rests with R&D not with I/S -CAD integrated with manufacturing control	-CAD, but development and maintenance responsibility rests with R&D not with I/S	-CAD, but development and maintenance responsibility rests with R&D not with I/S -CAD development complex and highly matrixed

CAD Investment Justification	-N.A.	-support product development and production -reduce costs -no systems evaluation until overload occurs -complex and use-discouraging charge-out methods	-support product development and production -improve quality and productivity -enhance knowledge worker productivity	-support product development and production -reduce costs	-support product development and production -enhance knowledge worker productivity -complex and use-discouraging charge-out methods
Banking Productivity	-rapid automation to cope with high turn-over rate for lower-level employees -each division has different system -corporate I/S as umbrella support group -justification satisfying user requirements quickly, with long-run flexibility to handle increased volume and functions	-N.A.	-N.A.	-N.A.	-N.A.
Organizational Structure & Productivity	-VP in charge of productivity	-no formal productivity framework, but much support for I/S automation -highly matrixed, so productivity improvements are difficult	-VP in charge of productivity -intense quality-orientation makes productivity relatively unimportant	-VP in charge of productivity, quality assurance & reliability	-senior manager of productivity has extensive control -formal productivity framework, emphasizing administrative productivity more than I/S -much management support

					-limited software experience but I/S position strengthened by its control over firm's telecommunications -highly matrixed -centralization of control limits employee creativity
I/S Productivity Link	-none	-none	-none	-none	-none
The Human Factor	-almost no interest in feedback to I/S -20-30% I/S analyst and programmer turn-over -direct reward system for cost-saving suggestions -relatively backward personnel standards -accounting group implements charge-outs and decides on cost-allocations	-belief that firm can gain by hiring people from other companies -insufficient understanding of how charge-out methods, training and documentation affect personnel -formal I/S training programs -poor documentation -accounting group implements charge-outs and decides on cost-allocations	-MBO extended down to non-exempt employees -quarterly evaluation of performance and adjustment of goals -salaries tied to MBO results -emphasis on development of I/S in-house with academic help -insufficient understanding of how charge-out methods, training and documentation affect personnel -formal I/S training programs -poor documentation -accounting group implements charge-outs and decides on cost-allocations	-insufficient understanding of how charge-out methods, training and documentation affect personnel -formal I/S training programs -poor documentation -accounting group implements charge-outs and decides on cost-allocations	-MBO extended down to non-exempt employees -quarterly evaluation of performance and adjustment of goals -salaries tied to MBO results -insufficient understanding of how charge-out methods, training and documentation affect personnel -informal training for CAD and manufacturing systems -poor documentation -rigid rules -accounting group implements charge-outs and decides on cost-allocations

Productivity Measurement	-no attention to effect of I/S on overall productivity -prime emphasis on labor productivity	-standardized CAD and engineering measurements -output as equivalent functions designed on a PC board or LSI -CAD through put; time also measured but with little resulting change -relatively thorough approach to automation productivity but prime emphasis on labor productivity	-standardized CAD and engineering measurements -output as equivalent functions designed on a PC board or LSI -CAD through put time also measured but with little resulting change -prime emphasis on labor productivity	-standardized CAD and engineering measurements -output as equivalent functions designed on a PC board or LSI (leading to 40% cut in design cost per board) -CAD through put time also measured but with little resulting change -prime emphasis on labor productivity	-standardized CAD and engineering measurements -output as equivalent functions designed on a PC board or LSI -CAD through put time also measured but with little resulting change -prime emphasis on labor productivity
Measurement of Quality	-measurement of systems availability and processing transactions errors	-low quality orientation	-N.A.	-VP for Quality Assurance and Reliability traces 85% of all quality problems to management mistakes	-effort to measure white collar work output quality
Effectiveness of I/S	-N.A.	-N.A.	-relative effectiveness increasing by changing batch programming to interactive end-user programs	-N.A.	-lack of software professionalism, computer access, sufficient terminals, centralized computer facilities, and clear processes for hardware and development resource allocation

I/S Investments and Productivity	-no explicit investment philosophy but formal investment evaluation methods like payback and ROI, not NPV goal: reduce headcount of departments using I/S	-no explicit investment philosophy but formal investment evaluation methods like payback and ROI, not NPV goal: reduce headcount of departments using I/S	-no explicit investment philosophy but formal investment evaluation methods like payback and ROI, not NPV goal: reduce headcount of departments using I/S	-no explicit investment philosophy but formal investment evaluation methods like payback and ROI, not NPV goal: reduce headcount of departments using I/S	-no explicit investment philosophy but formal investment evaluation methods like payback and ROI, not NPV goal: reduce headcount of departments using I/S

the military affects the firm's culture as much as it does the physical standards of production and productivity.

In manufacturing, Gruber is the only one of these firms with an explicit investment strategy and concise evaluation techniques. The other firms displayed a measure of frustration with their ongoing systems, which reflected their relative lack of advancement on this front.

Interestingly enough, the responsibility for CAD development and maintenance in the engineering sections of the high technology firms lay not with I/S, but rather with engineering or R&D. This separation between I/S and engineering reflects the disjointed nature of these firms' strategies. The bottom line for CAD investments is uniformly a financial one, even though it is clear to everyone that CAD has become essential in today's high technology environment.

At Atlasbank it is noteworthy that computerized automation is not linked to overall productivity increases. As in the other four firms, the I/S-productivity connection is neither acknowledged nor concretely addressed.

The most important effects of corporate structure appear to be the limitations imposed by excessive matrixing and organizational rigidity. In the case of Ratronics the lack of flexibility is a function of the firm's primary customer: the U.S. Department of Defense. But at the other high-tech firms complex organization can and should be adjusted to take into consideration the full potential effects of I/S on productivity enhancement.

The structures of the productivity programs in each of these firms clearly reflect the fact that the programs were established in response to cost and quality pressures, and not in order to improve productivity per se in the most effective way possible. The result: these firms can improve productivity within certain structural limits, but they cannot create it

through new investments that reflect more than just narrow cost or quality considerations. This problem is also reflected in the firms' disjointed perception of the relationship between I/S and productivity.

Human resources are affected by I/S and productivity programs in a number of ways. To begin with, because employees respond to a firm's culture, a comfortable culture might be the most basic step toward human resource management. But there's more to it than that. Reward systems, for instance, can be helpful or detrimental to employee satisfaction. Atlasbank, with its individual-oriented direct bonus system, would do well to consider that there are many other methods of improving employee motivation. (See Barocci, et. al., Productivity, Industrial Relations and Human Resource Management: Football on a Soccer Field, Working Paper #1358-82, October 1982) Furthermore, it is difficult financially to reward people who introduce productivity improvements that cannot be measured quantitatively, since it is impossible to figure out exactly what the cost savings will be. The personnel standards of the high technology firms are more advanced than Atlasbank's. But all of these firms could benefit by considering the indirect effects of I/S on the human resource function. Specifically, personnel are affected by charge-out methods for computer services, training for I/S users and documentation about the availability of I/S. None of these firms sufficiently understands these interconnections.*

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*Human Resource issues also encompass relations with organized labor, of course. Any measures that threaten job consistency and security must be handled with kid gloves. The mere concept of "productivity improvement" poses these very threats. To some degree, automation, CAD and manufacturing control systems must all be dealt with carefully if labor's fears about jobs are to be taken into account. Atlasbank had a relatively easy time implementing I/S, despite the fact that its labor relations are relatively underdeveloped. But labor's position is intrinsically weak in an enterprise with such a high turnover rate at the lower levels. And at the high technology firms, rapid industry and firm growth mitigate the fear of job losses through productivity improvements. In short, there are no formidable obstacles preventing management from establishing cultures that are sympathetic to productivity improvements.

Charge-out methods are unpleasant, but necessary. They are implemented by the accounting group in each of these five firms. And it is this group that decides on overall cost allocation. But that procedure is difficult on at least two counts. First, since users are rarely (if at all) involved with the design of the charge-out method, it is hard to strike a balance that is optimal for the corporation as a whole. Second, once a system has been acquired the firm must carry the costs of operation and depreciation regardless of how much it is used. It will be natural to try to get the maximum use possible out of the system. But in the process, the user is often penalized if usage is lower than expected; the result is that I/S use lacks creativity because the real relationship between cost and use, and the overall productivity of company capital, are neglected.

Most of the problems with charge-out methods can be dealt with by getting the responsible department together with users to develop a system that neither discourages computer use, nor leads to excess applications or facility overload.

It has become more than self-evident that it is hard to define and gather measurements for productivity in knowledge worker areas like I/S. The gap between the necessary and the possible is a big one. If for no other reason, then, it becomes important to consider the intangible and personnel aspects of future I/S projects. Unfortunately, intangibles are difficult to factor into an explicit I/S investment strategy. This is clearly reflected in the lack of such a strategy in all our case studies. But, once again, this results in a wide-spread inattention to I/S user needs, so systems seldom end up being as helpful as they could be -- in terms of productivity or otherwise.

The quantitative tools available for analyzing productivity are inadequate. Qualitative judgements are necessary as well. The productivity analyst should start with the following questions:

Who wants the analysis done?
What is it they want to know?
Who will be hurt?

Labor, capital and material productivity all involve and affect people in ways that cannot be accurately guaged. But investment decisions are generally made on the assumption that these effects are known. The result is often something that looks like labor productivity problems, but that is really a problem with capital. Labor productivity affects capital productivity and vice versa. So if investment decision makers want their capital and I/S investments to be cost effective, they must pay adequate attention to the effects on humans and intangibles. For example, by changing its batch programs to interactive end-user programs, Gruber is allowing users to define what kind of I/S are most helpful to them. This approach takes into account a wide range of intangibles that cannot be considered by financial control systems. The transformation of intangibles into accounting data is almost always inappropriate.

Undeniably, many of the improvements implied in this overview of the five firms' productivity programs and I/S are initially expensive. But potential long-run advantages are great enough that the trend is clearly (and should be) in the direction of bearing short-term costs in the interest of long-term benefits. In short, if you put a lot into these programs, you'll get a lot out of of them.

This point is illustrated by the results of our factor analysis of the firms' perceptions of the subject of this paper. We reduced our questions to a number of conceptual variables indicated in Figure 5: productivity measures, satisfaction, and I/S capabilities.

The differences clarified by this chart reflect the specific scope and intensity of each of these information systems and productivity programs. The programs clearly reflect each firm's approach to the I/S-productivity connection. Briefly, the factor analysis displays the following trends:

- -- firm satisfaction with I/S increases as the I/S or productivity program is more advanced or sophisticated;
- -- firm emphasis on measurement per se is more intense, the more aggressive its overall focus on productivity;
- -- firm perception of the impact of CAD is greater, the more engineering-oriented the company; and
- -- firm perception of the impact of manufacturing systems is greater, the more manufacturing-oriented the company.

These trends confirm the critical importance of the connection between I/S and productivity. When a company's approach to these issues is fragmented, several problems are likely to emerge. First, managers who are in different functions but are concerned with the same problems (i.e., productivity-related) will come at them from different angles. This often results in a duplication of efforts -- a waste of time and energy. Second, when the firm maintains a clear conceptual distinction between I/S and productivity it is liable to remain blind to the full potential for I/S-based productivity improvements. Third, and consequently, where there is an adequate I/S-productivity interface, I/S are likely to remain more distant from functions or projects that might benefit through I/S in terms of productivity. Taken together, these factors will make it considerably harder to make rational I/S investment decisions.

The factors analysis in Figure 5 reflects some of these very problems. Atlasbank appears worst off on all the dimensions discussed above. There is a patent lack of enthusiasm about I/S in general, as illustrated, e.g., by the bank's hesitant attitude about the I/S impact on users. The notion that I/S could substantially improve productivity has not been explored at Atlasbank; productivity is conceived of in terms of labor, and labor only -- and I/S is kept separate in deference to this special (and narrow) emphasis.

Figure 5: Factor Analysis

	ATLASBANK	COMPTECH	GRUBER	RATRONICS	SEMCON
PRODUCTIVITY MEASURES	relatively large emphasis on labor productivity measures	relatively large emphasis on quality and service as function of productivity productivity measures are important	relatively large emphasis on quality and service as function of productivity productivity measures in general are somewhat important	relatively large emphasis on labor productivity measures productivity is really not much of an issue	productivity measures in general are very important
SATISFACTION	least satisfied with productivity	most satisfied with production (along with Semcon) most satisfied with I/S	somewhat satisfied with productivity most satisfied with I/S	least satisfied with productivity	most satisfied with productivity (along with Comptech)
I/S CAPABILITIES	I/S considered to be important, but careful of impact on users	I/S considered to be important	CAD more important than manufacturing systems	not an issue	CAD more important than manufacturing systems

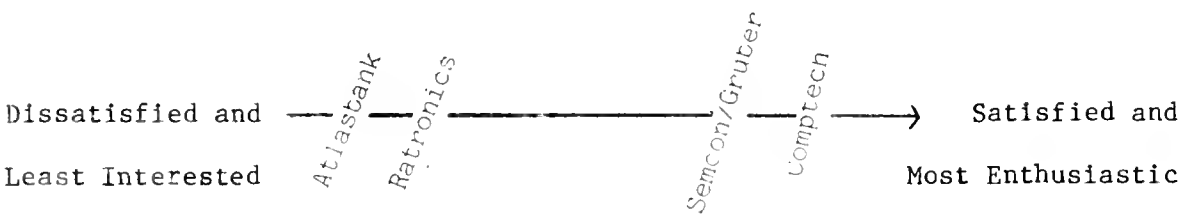
Figure 5A:

Factor Analysis Across All
High Technology Firms

	MANUFACTURING	ENGINEERS	CAD GROUPS
PRODUCTIVITY MEASURES	desire to measure productivity in terms of labor output, but less and less so productivity measures in general are clearly important	desire to measure productivity with regard to quality and service	labor productivity measures are unimportant productivity measures in general are somewhat important
SATISFACTION	relatively unsatisfied with productivity	relatively satisfied with productivity	general satisfaction with productivity programs in place
I/S CAPABILITIES	perceive little impact of I/S	perceive a relatively strong and positive impact of I/S	sufficient

Comptech comes out at the opposite end of the spectrum. Here, the I/S-productivity connection is almost explicitly acknowledged; enthusiasm about and satisfaction with each area seem to run high. Gruber and Semcon's approaches are both somewhat less holistic and less enthusiastic. Productivity measures per se are considered important, but the levels of satisfaction with both I/S and productivity are lower than at Comptech. Ratronics' approach is the least successful of all the high technology firms. There is virtually no I/S emphasis, and satisfaction with the productivity issues is very low.

Given a spectrum of "success" with I/S per se, the firms compare as follows:



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It need hardly be stressed that dissatisfaction and disinterest seem to go hand in hand, as do satisfaction and enthusiasm.

It is not easy to raise productivity through I/S. Emphases on profitability and quality often obscure long-term qualitative and intangible effects of I/S on productivity. Short- or medium-term financial justifications for corporate investments have the same effect. Post-implementation evaluations cannot be carried out effectively unless a firm's structure and culture allow for qualitative learning by experience, but it often seems easier to make these evaluations in quantitative terms, or to

avoid them altogether. Productivity measurements that focus exclusively or primarily on labor are easier and cheaper than more encompassing and intangible measurement techniques. The common lack of an overall I/S investment strategy makes it very difficult to design systems that interface with other functions in the firm. Productivity programs that are developed in response to specific pressures from outside the firm will tend to be incremental and partial, so productivity can be improved, but not infused or created in advance of outside pressures. The issue of human resource management has not yet been sufficiently linked with I/S, so users are too infrequently consulted about the kinds of systems that would be most helpful to them.

These problems may seem overwhelming at a disaggregated level. And they certainly explain why I/S decisions are so often taken as gambles. But in fact it is possible to narrow these down to the following issues, all of which can and should be tackled directly by management, in order to infuse some degree of rationality into the I/S decision making process.

First, managers should begin formally to consider the relationship between I/S and productivity. This should apply to all investment decisions about hardware and to the application of software projects. Such an approach must also take users into account at every step of the process.

Second, even when a firm's internal and external constraints make it impossible to 'do it right', I/S can still lead to substantial productivity improvements. The process will be incremental, and it may be slow. But it can be successful when analyses are clear, and when management is willing to make changes in organizational structure, and in technical processes, methods and tools (like I/S). Again, I/S implementation must take users into close account in order to become integral to the firm as a whole.

Third, managers must accept the fact that information systems are too often evaluated on the basis of inappropriate financial accounting methods like payback and ROI. The primary drawback of such measures is that they obscure I/S-related outcomes, and thus confuse the basis on which I/S investment decisions should be made.

Because the effect of I/S on productivity is complex and occurs over a long time period, we offer the following set of recommendations:

1. When making investment decisions, consider two kinds of investments:

   -- capital investments in fixed assets;

   -- investments in human resources that will help change the firm's strategy, structure or culture.

2. Evaluate each project in which you may invest along three dimensions:

   -- its economic value: use NPV when payback and ROI are inadequate, and make sure to consider costs and benefits across the entire life cycle of the project.

   -- its intangible value: consider how the project fits in with corporate strategies and objectives; avoid translating these issues into financial terms unless it really makes sense to do so.

   -- the productivity value of the investment over its entire life cycle: estimate the project's effect on input factors like labor, capital and material, and on qualitative issues like skill levels, capacity utilization, and so on. Keep corporate productivity objectives in mind.

3. Make your investment decisions on the basis of a clear corporate philosophy and a structure that will be conducive to productivity investment programs and improvements.

4. Consider carefully the impact of I/S on productivity increases, making sure to take into account both technical complexity and the necessity for structural integration. Consider alternative forms of organizational integration, charter, authority, user involvement and budget rules.

These suggestions apply to banking as well as to the high technology industry. The I/S and productivity-related issues that will be facing these two sectors over the coming years will look increasingly similar. The main reason for this similarity is that in today's world, I/S productivity -- and productivity in general -- has more to do with good management than with anything else.